Development of a long-term, Landsat-based canopy cover record for a semiarid grassland in southeastern Arizona

Mark A. Kautz[1], Chandra D. Holifield Collins[2], Sarah D. Russell[2]

[1]University of Arizona School of Natural Resources and the Environment, [2]USDA-ARS Southwest Watershed Research Center, Tucson, AZ

Background

Vegetative composition change following a period of prolonged drought occurred in grassland portions of the Walnut Gulch Experimental Watershed (WGEW) in 2006. Prior to high vegetation mortality in 2006, the vegetation community was mainly composed of mixed native grasses. The vegetation has since been dominated by the invasive bunchgrass, *Eragrostis lehmanniana* (Lehmann Lovegrass).

Previous research suggests that this shift in vegetation type may have altered the hydrologic response of the watershed, leading to increased runoff and erosion. Uncertainty remains as to what longstanding contribution this change has had on the watershed response, as historic vegetation monitoring has been limited.

Research Problem and Objective

While extensive historic hydrologic and climatic records exist for sites within WGEW, historic vegetation data is sparse both spatially and temporally. The vegetation records that did exist at Kendall helped to identify the vegetation shift and monitoring has been more intensive since. However, without a more complete record it is difficult to analyze long-term patterns in vegetation, effects from climate changes and impacts on hydrology.

Development of a long-term canopy cover record, coupled with historic hydrologic and climatic data could allow for improved analysis of processes within the watershed. Continuous multispectral data over the past thirty years from the Landsat series of satellites provides a means to construct a historic canopy cover dataset.

This research serves to examine the feasibility of creating such a dataset and validate the accuracy of the satellite-based canopy cover estimates.

Study Site

Kendall - WGEW Subwatershed 112

The Kendall subwatershed is a highly instrumented location within WGEW. The site contains rainfall, runoff and sediment measuring devices as well as a meteorological station with a flux tower, soil moisture sensors and a PhenoCam.

It is located within the Loamy Upland ecological site and the vegetation composition has historically been grass dominated.

Drought Induced Vegetation Shift

Historic data before 2006 showed the vegetative composition to be dominated by native grasses.

After several consecutive years of drought, high vegetation mortality occurred in 2006 and forbs took over the landscape.

Eragrostis lehmanniana (Lehmann Lovegrass) first appeared during the drought and since 2007 has been the dominant species in the subwatershed.

***Eragrostis lehmanniana* (Lehmann Lovegrass)**

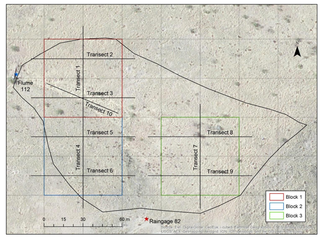
Methodology

Field Protocol

Canopy cover was measured on transects located at the Kendall site monthly from April – December, 2015 and on surrounding Loamy Upland grassland sites located on the Empire Ranch (2009-2011).

The point-intercept method was used on 80-m transects with measurements taken at 0.5-m increments.

Canopy hits were classified by plant life form (grass, shrub and forb) and as photosynthetic (PV) or non-photosynthetic (NPV). Ground cover hits were classified as bare soil, litter, rock or basal. Species were classified at peak growing season.



Kendall transect sampling arrangement

Landsat Image Processing

Ground measurements were timed to coincide with Landsat 5, 7 and 8 overpasses. Sixty-by-sixty meter study blocks (4 Landsat pixels) containing the transects were used for calibration and validation data for the Landsat imagery.

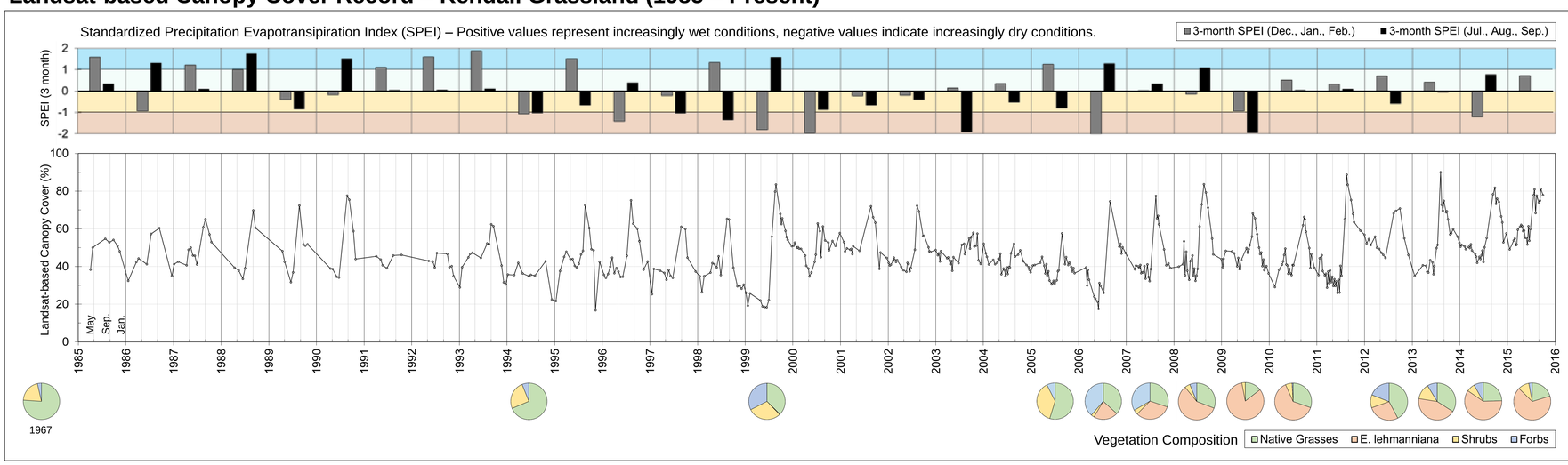
The Soil Adjusted Total Vegetation Index (SATVI) was calculated from the Landsat data. SATVI was used in this study because much of the grass canopy is senescent or brown for a portion of the year. Traditional greenness vegetation indices do not quantify this portion of the canopy well, leading to an underestimation of canopy outside of the peak growing season.

$$SATVI = \frac{\rho_{SWIR1} - \rho_{RED}}{\rho_{SWIR1} + \rho_{RED} + L}(1 + L) - \frac{\rho_{SWIR2}}{2}$$

A regression analysis was then performed between ground-measured canopy cover and SATVI to develop Landsat-based canopy cover estimates.

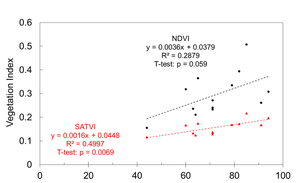
Preliminary Results and Observations

Landsat-based Canopy Cover Record – Kendall Grassland (1985 – Present)



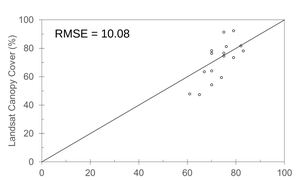
The Landsat-derived canopy cover record provides deeper insight to canopy cover dynamics than the limited historic transect data (years with pie charts) provides. Paired with SPEI (Vicente-Serrano et al., 2010) and vegetation composition data from the historic transects, the *E. Lehmanniana* invasion following prolonged drought can be clearly seen. The Landsat-based cover record also provides insight to intra-annual phenological patterns that are missed by annual transect readings.

Calibration



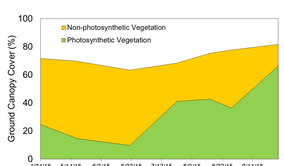
SATVI outperforms NDVI in relation to ground-measured canopy cover due to inclusion of dry or non-photosynthetic vegetation.

Validation



Modeled canopy cover shows reasonable agreement with ground observations (RMSE = 10.08). Further validation must be done to assess accuracy at lower canopy cover values.

Field Observations



Measurement of PV and NPV on transects illustrates the importance of including NPV in canopy cover estimates, especially outside of the peak growing season.

Conclusions

The creation of a long-term, Landsat-based canopy cover record for a semiarid grassland was feasible and demonstrated acceptable accuracy. Further validation must be done to fully assess the quality of the record.

Long-term paired datasets are essential for assessing the health of watersheds/ecosystems. Landsat provides great value towards these efforts with 30 years of continuous data.

It is necessary to consider dry or non-photosynthetic vegetation when measuring canopy cover in semiarid grasslands, as NPV often accounts for a majority of the canopy.

Continuing Work and Research Applications

Field-based canopy cover measurements will continue into the winter of 2015 to capture vegetation characteristics throughout a growing year.

Calibration and validation must be done at low canopy cover / high bare soil sites to ensure robustness.

The canopy cover record will be used in hydrologic analysis to assess if runoff and erosion responses have been altered in the watershed due to changes in vegetation.

Citations and Image Acquisition

Sergio M. Vicente-Serrano, Santiago Beguería, and Juan I. López-Moreno, 2010: A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. J. Climate, 23, 1696–1718.

SPEI 0.5 degree gridded data:
sac.csic.es/spei/map/maps.html

Landsat 5, 7, 8 surface reflectance data:
earthexplorer.usgs.gov
earthengine.google.org